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ADDRESSES BY

D. R. WILSON, Esq., M.A.,

(H.M. Inspector of Factories, and a member of the Home
Office Departmental Committee), on

"The General Principles and Practice of Industrial Lighting,"

AND BY

E. A. R. WERNER, Esq., O.B.E., B.A.

(H.M. Superintending Inspector of Factories), as to the

"Particular Requirements of Pottery Processes,"

at the NORTH STAFFORD HOTEL, STOKE-ON-TRENT,
on THURSDAY, 12th APRIL, 1923.

WITH REPORT OF DISCUSSIONS.

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DURING the afternoon session at the quarterly meeting of the National Council of the Pottery Industry, held on Thursday, 12th April, 1923, Mr. D. R. Wilson, M.A., (H.M. Inspector of Factories and a Member of the Home Office Departmental Committee on Lighting in Factories and Workshops), addressed the members of the Council and a large number of others who were in attendance on "The General Principles and practice of Industrial Lighting," and Mr. E. A. R. Werner, O.B.E., B.A., (H.M. Superintending Inspector of Factories) spoke with special reference to the particular requirements of Pottery Processes. Being of peculiar interest and importance to the Pottery Industry, which includes a number of "fine" and "very fine" processes, the Addresses were followed with keen appreciation and evoked many questions and an interesting discussion. Hearty votes of thanks were accorded Mr. Wilson and Mr. Werner for their Addresses, containing as they do, suggestions which will be of very practical assistance to the Council in the observations under actual working conditions which it has undertaken to make in co-operation with the Home Department to test the value of the proposed standards of illumination set up by the Departmental Committee on the Lighting of Factories and Workshops as a result of its investigations, and contained in the Reports published by the Home Department.

Council Offices,
6, Glebe Street,
Stoke-on-Trent.

Mr. D. R. WILSON.

The General Principles and Practice of Industrial Lighting.

INTRODUCTION.

INDUSTRIAL lighting covers such an extended field that it would be quite impracticable to-day to review the whole subject, however superficially. Had time permitted I could have put before you specific instances showing definitely the effect of lighting on accident prevention, production and hygiene, but the importance of good lighting in these respects is, I think, generally admitted and I do not now intend to do more than touch on certain aspects of the technique of illumination.

It is certainly true that in recent years much greater attention has been paid to the lighting of factories, but there still remains a good deal of misconception on the subject, and discussion is often rendered difficult owing to unfamiliarity with the technical terminology. For example, when one speaks of a temperature of 60°, one is understood at once, whereas the expression 3 foot-candles generally conveys no meaning until it is more or less elaborately explained. I propose, therefore, first to say a few words on this subject, referring only to the most common terms, and then to put before you some rather disjointed remarks on the subject of illumination generally, based chiefly on the proposals of the Factory Lighting Committee. Many of these may appear to border on the obvious, but it is a well-known truism that the obvious is often over-looked and nowhere more often than in a case like the present where one naturally tends to accept existing conditions as they grow more and more familiar.

Terminology.

1. *Luminous intensity.* The candle is the unit of luminous intensity, and is applied chiefly to the source of light. One speaks, for instance, of an 8, 16, 32 candle power source, meaning that the luminous intensity of the source is equal to 8, 16, 32 standard candles, (approximately the same as any ordinary candle).

2. *Illumination* is measured by the amount of light *received* on a surface, and can be expressed in terms of units of light flux incident on unit area of surface. In practice, however, it is usually expressed in another way, namely in terms of luminous intensity (*i.e.* candles) and distance. The unit employed is termed the foot-candle, and is defined as the illumination received on a surface placed normally (*i.e.* at right

angles to the direction of the light) at a distance of one foot from a point source having a luminous intensity of one candle.[1]

Illumination being the amount of light *received* on a surface is independent of the nature of the surface, and is the same, for instance whether the surface be white or black. This does not mean of course that the illumination *required* is the same in both cases, as will be seen in considering the next term to which I shall refer.

In dealing with illumination, three important laws must be taken into account:—[2]

(*a*) It varies directly as the candle-power of the source, *e.g.*, a source of 10 candles will under the same conditions give an illumination 10 times that of a source of 1 candle.

(*b*) As is generally known, the illumination varies inversely as the square of the distance from the source, *e.g.*, if a surface is placed 6″ from a source of one candle, the illumination will be 4 (not 2) f/c, if removed to a distance of 2 ft., the illumination will be ¼ (not ½) f/c., and so on. Hence the illumination increases (and diminishes) very rapidly as an object is approached to (and removed from) the source.

(*c*) The illumination varies according to the inclination of the surface. It is greatest when the surface is normal to the direction of the light, and with an inclined surface varies as the cosine of the angle of inclination. In most industrial processes the plane of work is horizontal, or nearly so, so that the ordinary system of vertical lighting is the best, but cases do arise where the plane of work is inclined or even vertical, and here this principle may become of importance. It is also relevant when considering the illumination of the floor or of an object some distance from the source of light. I shall refer to this point again later.

3. *Brightness* is measured by the amount of light *returned* from a surface, and is the most essential factor to be taken into account in

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[1] To reproduce various illuminations on a small surface for demonstration purposes the following method is recommended.—

Make a simple flat screen of dull black paper, cloth, or velvet, and attach it by means of a clip to an ordinary candle, so that the flame is completely invisible to the observer when standing behind the candle. Having completely darkened the room, light the candle and allow it to burn for at least five minutes. Then take a white unglazed card or piece of white blotting paper about 3 inches square, and fix it on a level with the flame in an exactly vertical position, preferably by means of a stand. Adjust the distance from the flame according to the table below, and the effect of the corresponding illumination, *as received on a white surface*, will be seen.

By using cards of different colours and shades the effects of various illuminations, *as received on other than white surfaces*, can be studied.

Horizontal distance of surface from flame.		Illumination (foot-candles) received on surface.
ft.	ins.	
2	0	0·25
1	0	1
	7	3
	5⅜	5

The above illuminations, especially the higher, are only very approximate, but are sufficiently correct for demonstration purposes. The appropriate distances for other illuminations can be calculated from the formula :

$$D = \sqrt{\frac{1}{E}}$$

where D is the distance in feet, and E is the illumination required.

[2] These laws apply, strictly speaking, only to point sources of light, *i.e.*, to sources whose size is negligible compared with their distance from the surface.

industrial work, since the power of seeing depends on the light returned from the object to the eye.

The brightness of a surface depends first on its illumination (*i.e.*, the amount of light received by it) and secondly on its *capacity* for reflecting the light received by it. For example, let us consider some process (such as hand-sewing) involving the use of differently coloured materials. If the material is white it will reflect about 80 per cent. of the light received, and with an illumination of 3 f/c its brightness or its degree of visibility will be measured by 2·4. If the material is black, it will reflect about 0·8 per cent. of the light, and with the same illumination its brightness will be ·024, or 1/100th that of the white. In order therefore, to bring the brightness of the black material up to that of the white the illumination must be increased one hundred times.

This example shows the important part played by the nature or colour of the object. The capability of reflecting light or the so-called "reflection ratio" is an essential factor to be taken into account whenever work involves the use of different kinds of material.

The term brightness has replaced the older term intrinsic brilliancy, and is now also applied to a light-giving source. It is then measured in terms of candle-power per unit area of surface. Brightness in this sense frequently arises in questions of shading and glare. In their Second Report the Factory Lighting Committee suggest that certain sources should be exempted from the requirements dealing with the placing of lights relatively to the eye. These sources are limited to those with a brightness of not more than 5 candles per square inch. I shall refer again to this point.

I now come to the more practical side of illumination and particularly those points which have been specially dealt with by the Committee under the two headings of adequacy and suitability.

Adequacy of Illumination.

I do not propose to say more than a few words on the subject of adequacy, for I would like to devote the limited time at our disposal chiefly to consideration of glare, etc., which to my mind are of greater and more pressing importance.

Adequacy has now been dealt with by the Committee in two of their Reports. In the first Report it was considered from the point of view of general lighting, that is of allowing easy access from one part of a factory to another, and certain standards were recommended as minima. For instance, a minimum of 0·25 f/c. at floor level was suggested for ordinary work-rooms.

The Third Report deals with adequacy from the point of view of the work, and, as you know, suggests that processes should be divided into three categories:—

(*a*) Very fine processes for which a minimum of 5 f/c. is suggested.

(*b*) Fine processes for which a minimum of 3 f/c is suggested.

(*c*) Other processes which it was thought might provisionally be covered by the recommendation in the First Report requiring a minimum of 0·25 f/c, on the grounds that this minimum at floor level would involve a much higher average at the working level.

It will be seen, therefore, that the question of adequacy generally has been treated in a rather tentative way. This I think is due, partly to the extreme complexity and extensiveness of the problem, which for complete solution would involve separate study of every industrial process, and partly to the feeling in the Committee's minds that definite legal requirements are undesirable at present. Indeed, so far as my experience goes instances of really inadequate illumination in the case of very fine processes are rare, simply because then the work cannot be satisfactorily carried out and the quality suffers.

There are however one or two practical points in connection with adequacy, which are perhaps worth mentioning, as they both relate to the best use that can be made of a system of illumination.

In the first place, any system of illumination depends for efficiency on its maintenance, in the case of direct lighting on the cleanliness and effective condition of the source and shade, and in the case of indirect lighting on the cleanliness of the ceiling and walls as well. From this two practical conclusions follow; first that inasmuch as half the possible light may easily be lost through dirty globes, defective gas-mantles, etc., it is in the interests of economy that these should be periodically cleaned and replaced.

Secondly, since the sources and decorations obviously cannot be kept in their original state of efficiency, allowance for deterioration should be made in planning any system to attain a given standard, and the standard initially reached should be considerably higher than that eventually aimed at.

Again, light is sometimes wasted (and unnecessary glare produced) by placing the source too low, under the mistaken impression that the illumination is thereby increased. Let us, for instance, imagine a double work-bench lighted by a single row of lamps down the centre. Here the source is not vertically above the place of work, and the simple inverse square law of illumination no longer holds, since the cosine law, to which I have already referred, also comes into play. I cannot enter further into this question now, except to say that in such cases there is one definite height of the source above the bench at which the illumination is at a maximum, and that fixing the source below this point not only increases the glare but also defeats its own ends in that the illumination is actually reduced. I have myself met with several instances when this point has been overlooked.

Suitability of Illumination.

If there is often little fault to be found with adequacy, the same certainly cannot be said of suitability, and I should say that the large majority of factories are capable of more or less improvement in this respect. I want, therefore, to enter rather fully into this side of lighting, and to bring to your notice certain fundamental points which, I think, should be taken into account when remedial measures are considered.

Glare. I will take first the subject of glare. The Committee distinguishes between three forms of glare. The first may perhaps be termed pathological glare, as it produces, or may produce, a definite lesion of the eye. It may be defined as the effect of looking directly at a bright source of light, whereby the eye is flooded with light. Extreme instances of this type of glare might occur in such processes as electric or acetylene welding, or steel making, but so far as I know protective glasses are universally worn, and in any case the effects produced would naturally have rather a medical than a technical interest. I do not propose, therefore, to say more here.

There is, however, a less extreme application of this type of glare which has a direct bearing on ordinary factory work, and especially safety. When a man even glances directly at a bright light, he is dazzled and his vision is temporarily impaired. The result is that, given the existence of some potential risk, his liability to accident is increased. Take for instance, a man entering a crowded foundry with unshaded high intensity light sources; his eye is adapted perhaps to almost complete darkness; on entering, a bright light strikes his eye, he is dazzled and fails to see an obstacle at his feet, and so his case becomes another addition to the long list of accidents due to persons falling. But for the dazzle effect he might probably have distinguished the object without difficulty. Similar considerations hold, of course, in regard to almost any process involving machinery in motion. I would like to lay special stress on this point, because to my mind it may prove to be as important a factor in accident causation as insufficient illumination.

The second form of glare which is really a modification of the preceding form, may arise when the material worked upon is polished or shiny. In certain positions, all detail become undistinguishable owing to specular as opposed to diffused reflection of the light. This effect is often observable in picture galleries where the pictures are glazed, when these are viewed from a certain angle. What happens, of course, is that the polished material acts as a mirror, and this type of glare differs only from the first in that the eye is confronted with an image of the source instead of with the source itself. I will come to the remedies immediately, but I may say here that glare is very liable to occur in any process dealing with polished material. It is so detrimental, and indeed prohibitive, to work, that it *must* be avoided by the worker, and if suitable objective remedies are not applied he is liable to adopt a strained attitude which may eventually have injurious effects.

The third form of glare is what I may term psychological. The mere presence of a bright source near the line of vision, even though the eye never actually perceives it, may be a cause of distraction and some annoyance. This may be due either to the rays of light striking the eye obliquely and reaching the periphery of the retina, or it may be of purely psychological origin. It is very common in practice, but is seldom the subject of complaint because the effects are not very intense.

I come now to the remedies for glare. These may be roughly classified into two groups:—

(*a*) The introduction of some protective measures between the eye and the light source.

(*b*) The position of the source relatively to the eye.

The first of these may assume various forms in practice. First, there is the wearing of coloured or smoked glass spectacles, which I have already referred to as being the only remedy in the cases of sources of very high intensity, which cannot be shaded otherwise. Apart from these, however, its use is generally confined to persons with defective eyesight.

Secondly, the light may be completely screened from the eye by means of opaque material. In adopting this method, care should be taken to ensure that the screen is sufficiently deep to prevent the direct light from falling on the eye and is yet not so deep as to cut off the light from the object being worked on. A fraction of an inch in this respect may make all the difference between a good and unsatisfactory system of screening, when, as is often the case, the eye and the object are placed close to one another.

Thirdly, the source instead of being completely screened, may be reduced in brightness until it is no longer harmful to the eye, even when looked at directly. The Committee paid special attention to this subject and virtually recommended that sources whose brightness does not exceed 5 candles per square inch (which is I believe approximately that of the sky) should be exempted from all restrictions, as regards glare. This reduction is most conveniently brought about by surrounding the naked source by a globe or other shade of translucent material such as opal glass. The effect of doing this is to make the globe itself the source instead of the mantle, so that the total candle-power is distributed over a much larger surface.

The reduction in brightness in any given case can be calculated quite simply. In general, the reduction in brightness brought about by surrounding a source with a translucent globe is at least equal to the ratio of the two diameters squared. Actually, of course, the reduction is greater, as a considerable fraction of the light is absorbed by the material of the globe, so that the total candle-power of the globe is less than that of the source itself.

I have entered into this matter in some detail in order to indicate how easy it is to bring down the brightness of a source to reasonable limits. For example, the brightness of a 100 candle-power gas mantle, would be reduced to the recommended limit of 5 candles per sq. inch by the use of a globe about 3 inches in diameter; that of a 2,000 candle-power arc light by the use of a globe less than 1 ft. in diameter, and so on. The criterion of whether the reduction of surface brightness is sufficient, as suggested by the Committee, is that the details of the source should be indistinguishable through the shade.

Having dealt generally with one type of remedy for glare, I would like to say a word about the advantages and disadvantages of two of the methods I have just described, namely, completely screening the source and shading it with translucent material.

Screening the source, especially if the screen is lined with white, has two advantages:—

(*a*) None of the light is lost through absorption.

(*b*) The light can be concentrated when *it* is needed.

It is therefore, specially suitable for the local lighting of work.

On the other hand, it has the disadvantage of diminishing the general lighting of the room, so that when it is adopted other units for the purpose of general illumination should be installed in addition. Further, it requires care in planning, and unless scientifically designed shades are used, glare, in the sense of the Committee's recommendations, is very likely to persist in the room generally, for it must be remembered that the relation of every person to every source within 100 feet must be taken into account, and it is quite possible to screen a source from the worker whom it serves and leave it exposed to other workers, such as those at a neighbouring bench. This is specially liable to occur when lamps of one size and shape are used in screens adapted for another, as is apt to happen whenever a new type of lamp is introduced on the market.

Shading as opposed to screening has the advantage of affording general as well as local lighting, though some light is lost by absorption. Also, when once a source is adequately shaded, glare is removed once for all and no question of position arises. In itself, therefore, it is perhaps preferable for processes in which specially good lighting is unnecessary. A practical point of some importance which, however, I need not further enlarge upon, is that all translucent *shades* are easily broken, whereas metal *screens* are not.

I now come to the second method of remedying glare, that is the position of the source relatively to the eye. The Committee closely considered this point and virtually recommended that no unshaded light source (unless below a specified brightness) should be visible within a vertical angle of 30° with the eye-level, if within a distance of 6 feet, or, if situated at distances from 6 to 100 ft, within a vertical angle of 20°. The following table shows the minumum heights at which such sources must be fixed in order to comply with the above requirements:—

Horizontal distance of source from eye.	Minimum height of source above eye-level.		Horizontal distance of source from eye.	Minimum height of source above eye-level	
ft.	ft.	in.	ft.	ft.	in.
1		7	9	3	3½
2	1	1¾	10	3	8
3	1	8¾	20	7	4
4	2	3½	40	14	8
5	2	10¾	60	22	0
6	3	5½	80	29	4
7	2	6¾	100	36	3½
8	2	10¾			

The above recommendation applies to every unshaded light source within 100 feet *relatively to every person employed in the room*, and, if adopted, will have far reaching, though, I am convinced, beneficial results. It will for instance eliminate all sources like naked arc lamps from large workshops, and will necessitate a thorough overhauling of the lighting arrangements in many factories.

Before leaving the question of glare, I would like to refer again to one common type which offers certain peculiarities, I mean the glare which is liable to occur with work on polished material and which I have already mentioned. In this case, as you will remember, the eye is confronted with an image of the source reflected in the material worked upon, so that the object itself is the origin of the glare and not the source of light. Hence *screening* the source from the eye is no remedy.

There are two means of overcoming this form of glare. The first is based on the relative positions of the eye and the source. It is a fundamental law of specular reflection that the ray of light falling on an object and the ray reflected from it are in the same plane. For example, when the working plane is horizontal, this form of glare can only arise when the source, object, and eye are in the same vertical plane, and if the eye or the object is moved slightly to the right or left the effect completely disappears.

The second remedy is efficient shading of the source. The ultimate effect of this, of course, is to reduce the brightness of the image of the source to a limit which can be tolerated by the eye without discomfort. Tissue paper is an excellent diffusing material, and I have myself seen this used with success to surround the light sources in the case of copper plate engraving, a process in which this type of glare is specially likely to arise.

Shadows. The treatment of shadows is in theory quite simple though in practice certain difficulties arise. In general, interfering shadows can be removed in three ways.

The first is what I may call the radical remedy. The depth of a shadow bears a direct relation to the size of the light-source, and as we shall see later, shadows in daylight are generally less pronounced than in artificial, because in the former the light is received from surfaces (namely the windows) instead of from points. Now, it is possible in artificial lighting to reproduce to some extent this characteristic of daylight, and that is by replacing the common system of direct lighting by indirect or semi-indirect. In these methods, of course, the light is no longer received exclusively from points, but in the former method all, and in the latter much, of it is reflected on to and back from the ceiling, which is a surface of considerable extent. In other words, the light in these cases is more diffused. Indirect lighting in fact is practically shadowless, and this very characteristic is something of a disadvantage; with semi-indirect lighting, there remains a faint but harmless shadow effect, but the general character of the illumination is usually considered to be preferable. These methods are best adopted in rooms with flat and not too high ceilings and are less suitable for the shed type of room, though they can also be applied here by the use of what are called false ceilings.

The second remedy depends on the relative positions of the light source and the object responsible for the shadow. It is clear that every shadow is cast in the same straight line as the object and source, and if in any one position a shadow is found to lead to discomfort it is often possible to remove it to another situation where it is harmless simply by altering the position of the source.

I have for instance often seen a compositor working in his own shadow cast on the cases by a lamp over a neighbouring frame; by moving this lamp a foot or two to the right or left, the man's shadow is no longer cast on his case but to the left or right of him.

The third remedy consists in eliminating or reducing the shadow effect, by placing an extra lamp in such a position that the part where the shadow is cast receives extra illumination. This is an obvious method which calls for no further explanation.

I may perhaps mention, that moving shadows such as are cast by parts of machinery in motion are often particularly trying. They often offer cases of considerable difficulty, but the effect can usually be overcome, or at least reduced, by one of the methods already suggested.

Natural and Artificial Lighting.

I have now dealt very roughly with some of the practical problems of industrial lighting, and before concluding would like to say a few words about the two great divisions of the subject, namely natural and artificial lighting.

Natural lighting, at any rate in modern factories, is, of course, far the more important in respect of the length of time during which it is in use. The Factory Lighting Committee have not paid much attention to it *per se*, but their recommendations as to standards of adequacy and such matters as shadows may be taken as applying to natural as well as artificial illumination.

There are, however, a few points relating to daylight to which attention should be drawn. Daylight is admittedly superior to artificial not only on account of the quality of the light, but also for other reasons. With daylight, for instance, the sources of light (the windows) are surfaces, instead of points as in the usual types of lamps. This fact makes the formation of shadows much less pronounced, and so to say increases the penetrating power of the light in cases where shadows are a difficulty. For example in the case of fine weaving, it has been shown that production in even good artificial light is 10% less than in daylight, and this I think is to be ascribed to reduced shadow effects which are such a hindrance in the case of certain types of loom.

Further, no acute glare arises in natural lighting, for the source of light (the sky) has normally a brightness which can be tolerated without discomfort by the eye. It follows then that (if we except direct sunlight), the greater the quantity of natural light admitted, the better. In fact, the quantity should be as great as structural exigencies admit, subject, of course, to realisation that a large expanse of window space makes a work-room specially susceptible to the cold and heat of the outside air. The eye can adapt itself without discomfort to large variations in illumination, and, if the direct sun (which may produce an illumination of several thousand foot-candles) is excluded, there is no risk of the illumination being too high. Neither is there any waste in this practice, for the greater the amount of daylight admitted, the later the lighting-up time becomes and the shorter the period of artificial lighting.

Apart from the question of window space, the natural illumination of a room can be greatly increased by the systematic observance of certain rules laid down by the Factory Lighting Committee in their First Report. First, all windows should be kept clean, for the obstruction of light by even slight dirt may be very heavy amounting easily to 50 per cent. The period between cleanings will, of course, vary with the nature of the work, but it is important that cleaning should be carried out systematically, and in some factories a man is employed to do nothing else. Secondly, windows should be kept clear of obstructions, such as large articles piled on one another, so that the light from them may have free access to the interior of the room. Lastly, the walls and ceilings should be clean and light in colour so as to act as efficient reflecting surfaces. This is especially important in small rooms, in which white walls and ceilings may increase the effective light fivefold as compared with black walls and ceilings.

I may say, that natural illumination has been much less studied than artificial, and there still remain many questions in connection with it which require to be cleared up. The whole question of natural lighting, however, is one *primarily* for the architect, and in old factories the only thing to do is to make the best of a bad job, and to apply the palliatives mentioned in the Committee's First Report, to some of which I have just referred.

There is, however, one important principle which is perhaps worth mentioning here. Every one is familiar with the superiority as regards lighting of a shed roof over side windows. This is largely due to the vertical direction from which the light comes. By extending this principle to side windows, it is easy to realise that the top part of the window is enormously more effective than the bottom. It follows, therefore, that windows should be constructed so as to reach right up to the ceiling, every additional inch in this part having a considerable effect.

Conclusion.

I would like to conclude this paper with two comments. As you will now have gathered, the theoretical requirements of good lighting are very simple and it is an easy matter to generalise in the way that I have just tried to do. When we come to apply these requirements in practice, however, we find that whilst there are certain fundamental conditions which every good system should fulfil, cases of difficulty, and even of extreme difficulty, frequently arise which can only be solved by the method of trial and error. I submit, therefore, that whenever a system of lighting is about to be installed in a factory, careful consideration should be given to these questions before the work is begun, and that before it is completed the employer should satisfy himself by actual experiment in the way of adjustment that the best conditions have been attained. For this work he will frequently rely on the services of some local firm of contractors, and often rightly so, for such contractors will probably possess special knowledge of the particular processes to be carried on.

I have myself seen many admirable examples of installations designed by local firms, but on the other hand I have often been in factories where every canon of good lighting has been broken simply owing to want of thought, for instance, the use of those wretched shallow conical covers (relics of the old carbon lamp days which ought to be completely abolished) instead of scientifically designed shades, wrong spacing of the points relatively to the plant, and many other faults.

If there are any contractors present to-day, I would submit to them that good lighting is a fundamental factor both in the comfort and well-being of the operatives and in production, and that it is a question deserving of much more attention than it has hitherto received in some quarters. In particular, I venture to suggest that in any new installation, special care should be taken to conform to the recommendations contained in the three reports of the Factory Lighting Committee, and the Home Office would, I know, be glad to be advised of any instances where this conformity appears to be difficult or impracticable.

Secondly, I would like to emphasise the way in which lighting differs fundamentally from other factors in the workers' environment, as this has an important bearing on the special difficulties inherent in the study of illumination. In the case of temperature and ventilation, convection and diffusion come into play, and we can safely say that the conditions at any point are approximately reproduced at any neighbouring point. In lighting this is not so; light travels irresistibly in straight lines and so it is often possible to find conditions entirely different as between one point and another a few inches removed from it. As a corollary to this, it follows that the satisfactory solution of a lighting problem often offers difficulties of a very special nature but on the other hand when once these difficulties have been overcome and satisfactory conditions have been attained, these remain unchanged and unaffected by external influences, which so often become interfering factors in the case of the other great divisions of factory hygiene.

The Discussion.

THE CHAIRMAN (Mr. Arthur Hollins) said that Mr. Wilson's paper appeared to have covered all conceivable phases of lighting in factories and workshops. Adequacy and suitability were the two outstanding features, and these had formed the basis of the paper. Of course, everything was wrapped up in these two points of adequacy and suitability. He himself thought, and most of them would feel, that it would be necessary to wait for a full report of the paper before they could give the subject the full consideration that it deserved. He believed that Mr. Wilson had given his views as simply as it was possible for him to do without making use of a good deal of terminology, and he felt that from what he had had to say they would be able to gather up a good deal of information which could be usefully applied by them on their factories.

Mr. JOSEPH BURTON said he would like to ask Mr. Wilson if he could make quite clear to them the exact difference that was implied between the two terms "indirect" aud "semi-indirect" lighting. Mr. Wilson used both terms, but he apparently did not made it quite clear what semi-indirect lighting implied.

Mr. WILSON replied that indirect lighting was a system of lighting in which the whole of the light was reflected from the ceiling. This was produced by means of a source like an arc light set in opaque surroundings, so that none of the light shone directly into the room. The whole of the light was reflected on to the ceiling and back into the room. He had pointed out in his paper that indirect lighting was practically devoid of shadows, which was something of a disadvantage for most processes. He thought this system of lighting had now been given up very largely in favour of the semi-indirect system. Semi-indirect lighting, simply expressed implied the use of a translucent bowl which allowed a certain amount of the light to fall directly upon the object, whilst the other part was reflected upon the ceiling. It was really a half-way house between direct and indirect lighting. It was probably the best system for general illumination.

A QUESTION was asked, what particular type of shade Mr. Wilson would recommend for direct lighting, with the idea of getting away from the old shallow shape.

MR. WILSON: "That is a question which it is very difficult to answer, because the actual formation of a shade depends very much upon the area you wish to illuminate. But all the big electrical companies have paid a good deal of attention to the question of shades, and there are now on the market some very scientifically designed shades. Some of these are rather deep and narrow so as to concentrate the light upon a comparatively small area; others are of a wider and more extensive type, allowing the light to reach a much broader area. But the main point about the shade is that it should completely conceal the naked source of light. The old shallow conical covers are not screens or shades in any sense of the word. They are simply dust traps."

THE QUESTIONER: "Would not what you suggest necessitate doubling the number of lights normally used in a workroom?"

MR. WILSON: "I do not agree at all. An unshaded light throws probably 70 per cent. of its light in a direction where you do not require it. It goes horizontally. With a scientifically designed shade you can collect this fraction, which would otherwise be wasted and direct it wherever it is wanted. I think it would be safe to say that it would be actually economical to introduce properly designed shades. But Mr. Werner will deal with the nature of the shades and the question of economy."

MR. SHAW said he would like to ask Mr. Wilson what was the strength of the brightness of the yellow colour. He had given them the strength of white and blue and it would be interesting to know about yellow. The reason he asked this question was that pottery workshops were lime-washed, and if an excess of blue were put into the lime-wash, from what he could gather this was ultimately detrimental to the light. If, on the other hand, no blue was put in at all the lime-wash gradually worked down to a yellow colour.

Mr. WILSON replied that this was a difficult question to answer without knowing the tint. It depended really upon the quality of the colour. If it was a dark yellow the reflection ratio would be very much less than with a white light. He should think it would be something like 40 per cent. instead of 80.

MR. SHAW said that the point he wanted to get at was whether light was lost by putting blue into a lime-wash, and whether if the lime-wash worked down to a yellow colour a bigger light would not be obtained than by having a limewash in which blue was used.

MR. WILSON replied that he should think if the blue was put into the whitewash to increase its whiteness that would be the best course to pursue. The right thing was to make the whitewash as white as possible whether this was attained by the use of blue or anything else.

MR. SHAW: "I am very much interested in this point. I admit that in the early stages the use of blue does increase the whiteness, but, if an excess of blue is used, in time the walls go bluer still, and in the course of 14 months or so the whiteness has gone. What I want to know is whether we can strike an average between the two."

MR. WILSON: "I am afraid I have had no personal experience of this point. It seems to be a matter in which you are between the devil and the deep sea, and I am sorry I cannot help you. It seems to me to be a question of experiment. Apart from what you have told me to-day, I know nothing whatever about this particular subject."

THE CHAIRMAN said he thought that quite a number of the fundamentals contained in Mr. Wilson's paper would be elucidated when they came to consider Mr. Werner's paper, and he thought, therefore, that it would be better to reserve any further questions until Mr. Werner's address had been read.

Mr. E. A. R. WERNER.

Lighting in Factories and Workshops.

Some Special Notes on Pottery Processes.

I.—Natural Lighting.

One of my colleagues on the Research Committee of this Council has asked me to deal first with questions of natural lighting, seeing that something like 4/5ths of all the work in a pottery (or more) is done during the hours of daylight.

I am inclined to think that most of our potteries, at the time that they were built, must have compared favourably with factories of a similar date designed for other industries. Pottery architects, however, as well as others, were oblivious, in those earlier times, of the value of light coming into a room at a relatively high point. We have only quite recently begun to realise the great value of the top of a window and the marked advantages which can be secured by carrying our window openings right up to the ceiling. Roof lighting, too, seems hardly to have been thought of in the older factories; although in Longton and other pottery towns the decorating shops were placed on the top floor in order to get more light, a skylight was a very rare feature. With the development of single-floor factories, saw-tooth roofs, providing ample natural light, have become practically possible; there are also a number of examples of dipping houses and placing shops which have been reconstructed with ample skylights affording admirable examples of natural lighting.

Where side windows only are practicable, it is unfortunately far too common to find that the light actually available is only a fraction of what the architect originally intended; in many cases, obstructions have been erected at a later date, either an additional oven or possibly an entire range of shops at too short a distance from the windows in question. In the great majority of potteries, moreover, far too little attention is paid to window-cleaning; this perfectly obvious requirement seems to be so completely overlooked at some factories that the glass becomes covered with a brownish coating and transmits only a fraction of the natural light that might be received; this involves many hours of additional use of artificial light in winter time; progressive firms who have introduced a system of regular window-cleaning, find that the cost that this entails is more than compensated for by the saving of artificial illuminant. Some of the older windows are constructed with excessively small panes of glass; this makes cleaning more difficult and the wooden cross-beams in some cases cut off an appreciable proportion of the light.

The next point to consider is the position of the workers relatively to the windows. In practically all potters' shops the favourite position appears to be directly facing the window; this practice seems to have stood the test of time and one, therefore, has some hesitation in questioning it in any way. Nevertheless, a sideways position with the window on the worker's right (or half-right,) has certain material advantages and might be worth experimenting with in potters' shops. The sideways, or half-sideways, position has been tried in some of the most up-to-date aerographing shops, also in certain throwing houses with excellent results. Needless to say, work-benches are frequently found in other positions, for example, against a blank wall between 2 windows; in the case of one large aerographing shop I remember finding the aerographers with their backs to the windows; it seems unnecessary to spend any time in pointing out the hopeless inefficiency of any such arrangement.

II.—Artificial Lighting.

Turning now to the subject of artificial lighting, I find that the first question asked me is usually, "Which is better, gas or electricity?" To my mind, very little practical purpose would be served by elaborating an answer to this question. As regards illumination, at least 9 rooms out of every 10 can be lighted equally satisfactorily either with modern incandescent gas burners or with electric lamps. The use of gas has certain obvious drawbacks in that the products of combustion of the gas help to vitiate the atmosphere of the room, and the smoke may dirty the ceilings and in some cases the reflectors used; it is less handy in the sense that it is more difficult to adjust the light to the exact position required than in the case of an electric lamp, though this drawback is to some extent diminished by the free use of metal flexible pipes; in particular, the cost of renewal of gas mantles is quite a serious item, and the only alternative to incurring this cost is to allow broken mantles to remain in use (one meets far too many cases of workers struggling along with inadequate light when the mantle has been broken and not replaced).

With regard to electricity, the colour of the light is sometimes urged as an objection, but, in practice, any tone of light desired is attainable without much difficulty; for example, electric lights are now very widely used to produce an artificial daylight for matching purposes, for the sorting of fine silk waste and the like.

The next question that arises is that of the best position for artificial lights in the various processes. This question has a sort of history of its own, because in days gone by, the potter doubtless worked with a candle stuck in a lump of clay, or in the neck of a bottle if he wanted the light a little higher than it would be if he stuck his candle in a lump of clay. When this era passed and gas was introduced, an ordinary Batswing or other gas burner was fixed, generally speaking, as near as practicable to the point where the candle-flame was before. Now that we are concerned with relatively intense lights such as those of the incandescent gas mantle or the electric metal filament lamp, it is essential that a new position be sought. The simplest way to do this is by the method known as trial and error, that is to say, a light is tried in several positions until the ideal position for it is determined. A few simple experiments in typical potters' shops might, with advantage, be carried out to determine what really is the ideal position. For many pottery processes, a point overhead and a short distance "half-right" of the worker appears generally suitable; often, however, especially where one light serves 2 workers, one finds workers with a most unsuitable "half-left" light; in at least one case I have found a jollier working with a light placed so far to the left that it threw a deep shadow of the profile arm (or "monkey's tail") right across the work; this was in a shop fitted with a modern system of high pressure gas lighting which provided a separate light to each worker. In another equally modern installation I found a handler who very wisely wore a large peaked cap to protect his eyes from the glare; the light, however, in its original position was so awkwardly placed that it threw a shadow of the peak of the cap across the work; this was rectified by bringing the light lower. In painting shops it is not unusual to find that the lights have had to be brought nearer the bench before sufficient illumination could be obtained and not infrequently the light has then to be tied back to keep the lamp away from the worker's face.

There are, of course, in potteries as well as other factories a number of departments (*e.g.* slip houses, warehouses etc.), for which special light at certain definite points is not requisite; the question of good general lighting for these places will be referred to later. There are also two groups of processes which present special features worth touching upon briefly, viz.(*a*) the processes for which exhaust draught hoods are required, *e.g.*, towing, china scouring, aerographing and groundlaying, for which many prefer a light so placed as to shine through the glass of the hood from the same direction as the natural light; and (*b*) the processes of setting-in and drawing ovens and kilns, for which it is desirable and well worth while to provide an electric lamp on the end of a long flex or a gas light supplied by a metal flexible pipe; either of these is more efficient and much safer than the portable oil lamp even when a good metal hand-lamp is available—it is not many days ago that I saw ovenmen at work with a tea-pot full of paraffin, the wick being inserted at the spout of the tea-pot; if a make-shift lamp like that is knocked off the bung of saggers on which it is placed, the chances are at least even that some of the paraffin falls on a worker and as a result his clothing is set on fire with horrible burns as the sequel.

Reverting to the most general problem of localised lighting for specific pottery processes, it would perhaps be convenient if I touched at this stage upon the much-neglected question of shading or screening lights to prevent the possibility of rays direct from the incandescent mantle or electric filament from striking the worker's eyes.

Generally speaking, the necessity for such screening seems to have been completely overlooked by the people who have installed the lighting in our potteries. Many workers have improvised paper shades to keep off the direct glare from their faces; these simple screens are often most effective and are well worth consideration when new lights are put in for similar work elsewhere. In one large decorating shop fitted with a new lighting system which would be nearly perfect if the lamps were screened, I saw a number of ornamental paper shades in position and was told that the decorators using these lights had asked to be allowed to keep up that part of the Christmas decorations; it seems a pity that some such "decorations" should not be kept on all the lamps all the winter through. If the shades adequately protect the workers' eyes from glare, there is, as a general rule, no further screening problem in pottery processes; the few exceptional cases include the work of engraving, where the light must be so arranged that no reflected rays from the copper plate will strike the eye; some engravers shroud their lights in thin tissue paper, thus diffusing the light and preventing glare and, in addition, obviating all dark shadows.

The question of the height at which lights should be placed is best considered in connection with the amount of illumination required. It will be convenient, therefore, to consider first what degree of illumination should be aimed at. I will quote briefly the minima recommended by the Lighting Committee, pointing out, at the same time, that these are minima and that the accepted standards of good lighting generally exceed these minima considerably; the average American good practice is, in most cases, several times the amount of the minima laid down by the Lighting Committee, which are as follows:—

(*a*) *For awkward corners in open-air yards, etc.*: Minimum, 1/20th foot-candle; (this slight illumination corresponds roughly to that provided by a 10 candle power light, 14 ft. above the danger point).

(*b*) *Passages, stairways and the like*: Minimum 1/10th foot-candle; *i.e.*, double the minimum for (*a*).

In connection with stairways lighted, as they frequently are, by a lamp at the top, I should like to call attention to the rapid loss of light as you approach the foot of the stairs. This often leads to insufficient illumination at the bottom of the staircase.

(*c*) *Over the floor area of work places*: Minimum ¼th foot-candle; (this corresponds approximately to the illumination of a point on the floor by a 20 candle power light at a height of 9 ft.)

(*d*) *For ordinary work at bench level*: No specific minimum is recommended by the Lighting Committee, but a suitable minimum would be about 2 foot-candles; preferable standard 3–4 foot-candles.

(*e*) *For fine work, such as aerographing, ground-laying, etc.*: Minimum 3 foot-candles; preferably 5—6 foot-candles.

(*f*) *For very fine work such as enamelling and gilding, also engraving*: Minimum 5 foot-candles; preferably 8—10 foot-candles.

Some of the very fine work calls for extremely good illumination, for example, gold painting on a deep blue such as oven blue. So far as I have been able to make observations as yet, I am of opinion that an illumination of 10–15 foot-candles is desirable for such work; the American practice suggests 10–20 foot-candles for similar fine painting work.

Once the degree of illumination is agreed upon, the next consideration is how best to secure it. For the purpose of illuminating the work itself, obviously a well-shaded light above the work is ideal. But in nearly every workplace it is essential to have a certain amount of general illumination at other parts of the room; for example, in a jolleying and jiggering shop with dobbin stoves, there must be sufficient general light to enable the mould runner to see what he is doing at the dobbin, as well as a good light on the jigger. Now the usual way of meeting this double need in a pottery appears to me to be unsound; the lights are raised several feet too high over the benches, and the shades are flattened and spread out to such an extent as to render them useless as screens. As a result the jiggerer gets too little illumination on his work and every worker in the whole shop is exposed to glare from the unshaded lights. Moreover, this most common system of artificial lighting is decidedly the reverse of economical.

Let us take a specific instance where, say, an illumination of 5 foot-candles is required at the bench. This can be obtained by:—

a	5	candle power light	at	1ft.	directly	above	the work.
or a	10	,,	,,	1′ 5″	,,	,,	,,
,,	20	,,	,,	2′	,,	,,	,,
,,	80	,,	,,	4′	,,	,,	,,
,,	180	,,	,,	6′	,,	,,	,,

Now the employer or his contractor, bearing in mind the need for giving some light to the stillages or dobbins, rejects the lower positions in this table and considers only the higher positions; 4 ft. over the bench will not give light enough at the top of his stillage or dobbin, however flat he makes the shade or reflector over the light; 6 ft. over the bench will take too much gas or electric current to produce 180 candle-power. Like everyone who is trying to make the best of two different worlds, he compromises and says "I'll put the lights about 5 ft. high and I'll put in 100 candle power lights; that will surely give everybody in the shop enough light." It certainly causes enough glare to make everyone say "What a well-lit shop!" but you have to remember to keep your head well down because, if you look up momentarily, one of the several unscreened lights is sure to catch your eye and make it impossible to see other objects clearly for some seconds; the result, in short, is in every respect the reverse of restful to the eyes. What about the workers at the bench? Vertically under a light the illumination will be 4 foot-candles only and less in proportion as the position of the work deviates from the point vertically beneath the light. So, at the point where you want a good light, you are not getting as much illumination as you set out to get, notwithstanding the large amount of dazzling light spread about the rest of the shop.

Now let us consider an alternative, namely, working out the two distinct problems independently. Take first the bench illumination of 5 foot-candles at the working point: a 5 candle power light 1 ft. away might be inconveniently low and a 10 candle power light at 17 inches up would have to be vertically over the work; we shall probably want the light a little in front of and to the right of the work. Let us, therefore, take a 20 candle power lamp and try it about 18 or 20 inches up; this will give over 5 foot-candles of illumination on the work with a relatively wide range of positions (up to 2 ft. directly above the work) in the section of space on the worker's right front. Having, by the method of trial and error, secured the best position for the light, within this range, let us see that the shade is so adjusted that no part of the working area can possibly be in shadow, but that the edge of the shadow falls below the worker's chin so that under no circumstances can the direct rays from the filament or gas mantle shine into the worker's eyes. As all other workers will be further away from this particular light, we know that they also cannot be subjected to glare. When each working bench has been dealt with in this way we shall have an ideal illumination at each working point, not necessarily with a separate light for each worker; while a separate light is clearly desirable at each lathe or jigger in a potter's shop, in a decorating shop 2 workers on opposite sides of a bench of moderate width and often 4 workers (2 on each side of the bench) can work from a light placed and shaded as described.

We have still to cater for the general illumination of the room; a very few lights placed high up with opal bulbs hung below them, on what is known as the semi-indirect system, will provide quite adequately for this; one such light of 100 candle power placed 10 ft. from the ground will give all the general illumination needed for quite a good-sized shop.

To illustrate the economy effected we need only take a small shop with 6 working points; with medium-height unscreened lighting, there are 6 lights each of 100 candle power, total 600 candle power; with 6 screened individual lights of 20 candle power each and one general light of 100 candle power, the total is 220 candle power, burning only just over one-third of the gas or electricity although better lighting has been secured. For larger shops, the economy becomes even more striking because relatively few big semi-indirect lights can be placed higher to cover a wider area and, where electricity is available, large gas-filled lamps can be utilised; these burn much less current, per candle power, than smaller lamps.

Where no fine work is done, the general illumination by semi-indirect lights is sufficient in itself; I have here several large photographs showing illumination of this kind, which is ample for mill and sliphouse work, sagger-making and many other departments (including most casting shops) as well as for much of the general warehouse work; where pieces have to be looked over carefully in a warehouse, one or two benches with individual shaded lights (like those recommended for decorators) can be provided in addition to the general illumination. In one large warehouse I found an illumination in use of approximately 3 foot-candles at bench level throughout the room and 20 foot-candles at the spots where the ware was carefully examined. These standards seem excellent for such purposes, and a general illumination of 3 foot-candles at bench level is very readily maintained, without hard shadows, by the semi-indirect system.

This system is, of course, most readily adaptable to rooms with a flat white ceiling, but plenty of fittings are on the market with reflector tops to take the place of a white ceiling. I have here illustrations which are open to inspection and may be passed round, showing bowls for both gas and electricity. Existing flat-shaded lights (both gas and electric) can easily be fitted with an opal bowl, where the candle power is sufficient to make these suitable for semi-indirect lighting. It is hardly necessary to add that all such bowls should be so fitted as to open readily for cleaning or, in the course of time, results will be achieved similar to those with natural lighting in factories where the windows are never cleaned.

I fear my address has been somewhat more lengthy than I had intended; but it seemed necessary to go into one or two of the problems arising in a pottery, in some detail. On a subject like lighting it is only possible to generalise to a very limited extent. In the first place, a short practical research is needed to determine exactly the best position and intensity of the lights for each process in the industry, and this could be carried out at a few typical works for the whole industry. Then the individual little problems of each different workplace remain to be considered, but, if these be tackled in detail, it will prove quite a simple matter to solve them in accordance with the guiding principles of good factory lighting.

The Discussion.

MR. A. DOUGLAS asked whether Mr. Werner could make any recommendations as to the best types of reflectors to use.

MR. WERNER replied that for simplicity's sake he had avoided expressing any opinions in his paper in regard to this point. But obviously lamps with a suitably designed reflector close down to the bench did tend materially to concentrate the light. Therefore, instead of having five foot-candles one would have considerably more, whereas, a dispersive reflector would give nothing like the same degree of focussing power.

MR. DOUGLAS added that the point he was trying to make was this: There was nc necessity to keep the lamps at two feet above the table top. In this event the number of points required would be enormous, whereas, if a focussing reflector were used, it could be taken higher and yet afford the same degree of illumination as with smaller lamps. Apparently, from Mr. Werner's figures, the candle powers were based simply on the inverse square law without any reference to any particular type of reflector. But the whole subject was bound up with the type of reflector used.

MR. WERNER said that if they were using a lamp with a reflector which functioned so efficiently as to produce materially more than the illumination that was obtained from the inverse square law, then obviously that lamp, placed somewhat higher, must be regarded in much the same category as the lamp with an ordinary conical reflector placed somewhat lower. But it would not help the general illumination. He thought they would agree with him that a general light in the centre of the room, for illuminating stillages and so on, was necessary.

MR. DOUGLAS replied that he was not referring to the general lighting of the whole room.

MR. WERNER: "The point raised is a perfectly good one. So long as you are getting the necessary concentrated illumination there is no doubt an advantage to be gained by using a type of illumination which enables you to put the lamps somewhat higher out of reach. But, as a matter of fact, from practical experience in the Potteries I have found that the great majority of the lamps provided for local lighting, both gas and electric, are placed at a height of about two feet. I have measured quite a number of lamps at jolleys, lathes, throwing wheels and so on, and they are generally about two feet or two feet six inches above the wall. It was for this reason that I selected two feet."

MR. D. H. OGLEY said he would like to ask why Mr. Werner chose a half right-hand light instead of a half left-hand light. He thought it was pretty obvious that a left-hand position was often preferable. One might take the case of a clerk who was writing in a book; he would work very much better with the light slightly to the left than if it were placed to the right. In much the same way a potter, using a jigger and operating the handle with his right hand, would get better service from the light if it were placed slightly to the left than slightly to the right.

MR. SEDGLEY pointed out that in his experience the jiggerer used his left hand to operate the arm and the half-right lighting was correct.

MR. WERNER said he quite agreed that it was wise to apply the principle of trial and error in the broadest possible way. Where one had a jiggerer who used his right hand to operate his machine, that man should have a left-hand light, seeing that the left side was the open side. But more often the left hand was used by the potter, and he used his sponge and his rubber with the right hand. In the same way, with clerical work or anything else, it would be necessary to consider the different positions in which the people habitually did their work.

MR. OGLEY came back with his point by referring to a sketch shown by Mr. Werner of a decorator. There was no doubt that for a decorator, working with a pencil with his right hand, the best position for the light was the left-hand position. The conditions here were precisely the same as with a clerical worker writing in a book. Again, the inclination of a plate would be about 10 degrees to the near side of a person working at a table. From the illustration which Mr. Werner had produced it would appear as though the efficiency point would be very low.

MR. WERNER: "Of course, it must be remembered that many of the decorators work on a whirler."

MR. OGLEY: "But on your sketch the rays of light practically miss the article on which the decorator would be working. They almost strike the edge of the plate."

MR. WERNER: "The questioner has discovered exactly the point to which I called the attention of the friend who was good enough to redraw this picture from my rough sketch. I unfortunately omitted to explain to him before he copied the sketch that the usual practice is for decorators to work from the top of a whirler placed at the edge of the bench. But as you see, there is plenty of margin. I made it clear in my paper that the lamp ought to be arranged so that the edge of the shadow falls just below the worker's chin."

MR. OGLEY: "But the worker's chin in your sketch is not in a correct position; it is not sufficiently low to do the work. The worker is sitting upright instead of at an angle of about 45 degrees."

MR. WERNER: "You might also have pointed out that there is a back on the chair, which is not usual in a pottery."

A QUESTIONER asked whether Mr. Werner had any information regarding the standardisation of lamps. Considerable difficulty was experienced at the present time in using various types of lamps with particular types of reflectors. The lamps varied very much in size. Had Mr. Werner any information regarding any standards likely to be fixed in the near future? When certain lamps were installed to existing industrial types of reflectors it was found that the lamp filaments of one particular make of lamp were lower than the rim of the reflector, whereas in the case of another type the filament would be well inside the reflector; so that in the former case the worker would be subjected to the glare which had been condemned in the paper.

MR. WERNER said that Mr. Wilson would probably be able to answer that point.

MR. WILSON observed that all the big makers of lamps designed shades to suit their own lamps. It amounted to this: each type of lamp required its own reflector; otherwise one was always liable to glare. This was a great difficulty. He had seen admirable reflectors fitted with the wrong type of lamp and the glare had been very pronounced on that account.

THE QUESTIONER pointed out that often the reflector manufacturers did not make lamps.

MR. WILSON: "But all the big electrical lamp makers design shades. The point you raise is one that should be taken up with the makers. The difficulty is one that might throw out a whole installation. You may get a "Mazda" lamp for the first supply, an "Osram" for the second and an "Ediswan" for the third, and they all vary in size."

MR. A. B. JONES, JUNR., in proposing a vote of thanks to the lecturers, said that there was an old saying that fools stepped in where angels feared to tread, and he was reminded of an old but true tale told of the late Mr. John Aynsley, who, on being shown round a garden by the gardener, was told one by one all the Latin names of the shrubs. Mr. Aynsley did not know anything about Latin, and he assured his informant, after he had got all the information, that he could rely upon his secrecy. This was just how he (Mr. Jones) felt that afternoon. After the intelligent questions which had been asked by men in the audience he was not going to pretend to ask any himself, because it was impossible for him to put his questions with the same amount of intelligence that had already been displayed. He felt that both in regard to adequacy and suitability of lighting they had learned something from the papers and the discussion. He thought they would all be pleased to know that the manuscripts which the lecturers had read were going to be placed at their disposal so that they could be printed and read at their leisure. He felt sure it would be to their great benefit.

Mr. Wilson had not the same knowledge of their surroundings as Mr. Werner, but on the scientific side he had been very instructive and he had no doubt that his remarks would be the more so when they had more time to read and digest them carefully. Mr. Werner took them at a disadvantage, because he knew all their past sins of omission regarding dirty windows, dirty walls and dirty ceilings. He knew of the teapot with the wick in the spout, and, therefore, he had a subject before he was well on the way. But all present would fully approve of the vote of thanks that he was about to propose to Mr. Wilson and Mr. Werner for their admirable papers. He had not the slightest doubt that they would all profit very greatly from the reading of the two papers, and it was very kind of the essayists to put the full text at their disposal.

MR. W. TUNNICLIFFE seconded the vote of thanks. He said he was sure that all of them had got some food for thought out of the two papers and the discussion which had arisen upon them. There was one point in regard to natural lighting (in which they did the major portion of their work) and this was worthy of further consideration and development. He referred to the side lights, or the half-righthand lights, to which Mr. Werner had made reference. Unconsciously, the potter resorted to these side lights whenever he was in doubt. Anyone who had watched a potter when he was examining a piece of work would have noticed that where a window came directly in his face, and the light streamed in upon him, he would very often get to the side of his piece of ware so as to be more sure. Here, then, was an idea that could be worked upon insofar as natural lighting was concerned to the benefit of both the worker and the work done. He was perfectly sure that the technical points which had been advanced by Mr. Wilson, and the practical applications which had been given to them by Mr. Werner would, within the near future, as and when alterations could be made on factories, be borne in mind, and an attempt made to give proper effect to them in the interests of the comfort of the workers and the facilities for improving production, in which he felt sure everyone was interested. He did not think there was anything that appealed more to them than a decently-produced piece of work, and to this end he felt sure that both from the technical and practical sides of the problem the thoughts which had been put before them that afternoon would be seriously considered. He had much pleasure in seconding the resolution of thanks moved by Mr. A. B. Jones to the lecturers for the able and yet simple manner in which they had put their views before the lay minds, thus enabling them to grasp the main points at issue.

MAJOR FRANK H. WEDGWOOD supported the vote of thanks. He said he had listened with very great interest to what had been discussed that afternoon. To a certain extent he felt like Mr. Aynsley; it was a little bit above his head; but it would set them all thinking, and they must try to read the papers through carefully when they came round to them later. There was one Latin phrase that he remembered very vividly from his schoolboy days, and that was "*Ne crede experto*"—"Don't believe the experts." In this particular case, however, he thought they really ought to believe the experts, because he thought that within the next ten years or so they might look forward to an enormous activity in the Potteries in getting their works brought up to modern principles. If they had a revival of trade, new buildings would be springing up in all parts of the Potteries, and they would have to study these lighting questions carefully, in all their bearings, along with the rest of the features of the buildings. He was very glad to feel that they had that afternoon a considerable audience, besides the members of the National Council of the Pottery Industry, of managers and other people interested in lighting, and he would like to feel sure that whenever they had new buildings to erect or old buildings to remodel these gentlemen would take the greatest pains to put them on the soundest possible basis. He was sure that Mr. Werner would be quite prepared to discuss with them the problems of each individual works as they came along. The expert should be called in to advise them, in spite of the Latin tag to the contrary, which he had quoted in his earlier remarks. He had great pleasure in supporting the vote of thanks to the lecturers.

MR. A. HOLLINS said that in December of last year, they received a communication from the Secretary of State that there had been certain publications with regard to the inquiries that had been made into the puestion of factory and workshop lighting, and their observations were sought in regard to them, as well as their help in making these things more widely spread. Their Research, Inventions and Designs Committee decided to help in disseminating the knowledge, and at once they asked the Government if they could have the services of Mr. Wilson and Mr. Werner. He thought everyone would agree that they had made an admirable choice in mentioning these two gentlemen. Happily, the Secretary of State willingly agreed that they should come to address them. They were all hoping to go further into this matter of factory lighting, but they felt that it would be well to have these two lectures first. The Research Committee would go on with its enquiries in the directions indicated by Mr. Werner and Mr. Wilson, and possibly they would publish a sort of Interim Report, which would guide the Council in this matter. It was also felt that it would be something of an advantage to the experts in regard to lighting if they came to that meeting and heard of some of their difficulties on the factories. He only wanted to mention this matter in order to prove that they did intend to go forward and to make experiments.

MR. WILSON, acknowledging the vote of thanks, said it was quite true, as Mr. A. B Jones had remarked, that his knowledge of the pottery industry was limited, but he had certainly some knowledge of the principles which actuated the National Council of the Pottery Industry, for he had been in touch with it for some years in connection with other industrial research work that he was doing. It was always a great pleasure for him to attend a meeting of the National Council, as he was immensely struck by the receptivity of this particular Council. He had always felt that the National Council of the Pottery Industry was particularly open to new ideas, and he was very glad indeed to hear from their Chairman that this discussion would not be lost sight of, but that it would be carried further, and possibly some report eventually issued on the question of lighting. He had been interested in this question of illumination for some years, and he was quite convinced that it was a really important subject, so far as the well-being of the operatives was concerned. If more attention were paid to it, not only in the pottery industry, but in many others, the better it would be for all concerned. He had with him an illumination photometer, which was actually used for measuring illumination. If anyone would like to see it, he would be pleased to explain its functions. He had been very glad to come down to talk to them, and he hoped that some day he might, perhaps, be asked to repeat the experiment.

MR. WERNER said he would like to express exactly the same sentiments as Mr. Wilson. He had no need to say what a pleasure it was, amid his more varied work in Birmingham, to have the opportunity, although it was also a responsibility, of preparing the present paper for the consideration of the National Pottery Council. There was only one point he would like to touch upon just now, and that was Major Wedgwood's suggestion that the people who were responsible for the designing of new installations in the Potteries should have an opportunity of discussing with him any problems which they might feel they would like discussed. He would like to say that anything that he possibly could do he would be willing and glad to do, and his promise he knew included not only his own services, but those of Mr. Beverley and the various members of his staff, several of whom were present.

MR. JOSEPH BURTON said he would like to add just one word, as the Chairman of the Research Committee, which was intending to take this work further. It was this: he hoped that, as a result of the lectures that afternoon, those people who were present would not wait for any further report before they began to move in the matter of lighting, particularly with regard to the cleaning of windows, the lime-washing of walls and the white-washing of blank walls outside windows, where the buildings had been put too close to the windows. He sincerely hoped that a move would immediately be made in this direction, apart altogether from the question of dealing with artificial lighting on the lines suggested by Mr. Wilson and Mr. Werner. He himself found that it paid as a commercial proposition to whitewash a room two or three times within the fourteen months allowed, rather than once only. He was quite certain that it would not be putting a manufacturer to expense by giving a room three coats a year, but that it would save him money, as well as bringing better lighting conditions for the worker.

The meeting then terminated.

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Pottery Industry
Lighting in factories and
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